Journal of the Arkansas Academy of Science

Volume 28 Article 15

1974

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ABSTRACT

Piney Creek is a clear medium-size tributary of White River in a region of the Ozarks that is undergoing rapid environmental change. Piney Creek is characterized by a very diverse ichthyofauna, although increased sedimentation due to poor agricultural practices and gravel mining threatens to destroy much natural habitat and eventually may cause extirpation of some species. The wide diversity of 44 species is related to variety of habitat and the proximity of a large reservoir, and not to differences in the physicochemical environments. Fish density ranged from 15,100 to 21 fish/ha, greatest concentrations being in headwater pools. For the three most numerous cyprinids, mean weight per individual was greater in pools than in riffles. ***Okkelbergia aepyptera*** **was collected for the second time in Arkansas (Harp and Matthews, in press), and a range extension for** ***Notropis sabinae*** **is reported.**

INTRODUCTION

Piney Creek drains western Izard County, in a region of the Ozarks undergoing rapid alteration of its natural state because of an influx of tourists and increased recreational land use. Poor agricultural practices, gravel mining and indiscriminate stripping of trees and underbrush have drastically increased flooding and the amount of sediment borne by Piney Creek and other Ozark streams, and have resulted in some areas in the extirpation of organisms intolerant of silt (Black, 1940). Natural history surveys are imperative now, before increasing environmental change further disrupts the original unique Ozark ecosystems. This study constitutes a preimpoundment ichthyofaunal survey of the Piney Creek watershed. Reservoir construction is recommended by the "Comprehensive Basin Study - White River Basin - Arkansas and Missouri" (White River Basin Coordinating Committee, 1968). The only previous study of Piney Creek was a limited survey by the Arkansas Game and Fish Commission (Baker, 1953), which provided no quantitative data on fish populations or biomass and failed to identify the forage species.

DESCRIPTION OF AREA

Piney Creek is within the Salem Plateau of the Ozark Highland physiographic province (Croneis, 1930), in an area characterized by rugged hills and steeply sloping creek valleys. Important geological units are Cotter Dolomite, Calico Rock Sandstone with Powell Limestone, Everton Limestone and St. Peter Sandstone, all of Ordovician origin (Arkansas Geological Survey, 1929). Major soils include Razort in the bottomlands and Hartsells-Linker and Sogn-Mountainburg associations on hillsides (Soil Conservation Service, 1971). Razort soils are neutral to acid, brown or dark brown, with loam or silt throughout, and are deep, well-drained and moderately permeable. Hartsells-Linker soils are moderately deep, well-drained, moderately permeable, acid and loamy. Sogn-Mountainburg soils are shallow, well to excessively drained, moderately permeable, acid to neutral and loamy (Soil Conservation Service, 1971). Sogn soil is very poor for septic tanks because of a low capacity to filter and hold liquid, and allows unfiltered effluent to run off during heavy rains (Soil Conservation Service, undated).

Piney Creek arises along the Izard-Fulton county line as unnamed tributaries converge (Fig. 1). It is a cool-water stream of medium size flowing southwest 47 km to its confluence with White River. Mill Creek, originating from numerous tributaries near Melbourne, Band Mill and Brockwell, is the largest of nine named tributaries (Fig. 1). Several of these tributaries are intermittent, as is much of the headwaters. Much of the watershed is spring-fed; during the study seasonal fluctuations of flow were pronounced because of runoff. Width ranged from 4 to 27 m and mean depth was 95 and 33 cm for pools and riffles, respectively. Gradient was 2.1 m/km between the uppermost Piney Creek station, elevation 180 m, and the confluence with White River at 94 m elevation.

Oak-hickory forest borders much of the creek, although pine

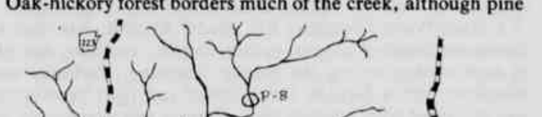

Figure 1. Piney Creek watershed, Izard County, Arkansas. Locations of sampling stations for the study are designated by letter-number combinations.

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was common prior to timbering early in this century. Pasture is common and livestock have access to the creek at numerous locations. No channelization has taken place, but limited sand and gravel digging contributes to the amount of silt carried during high water. The creek bottom ranges from large broken rock and bedrock to unstable sand which is characteristic of the lower stations. During the study detritus was moderate; muddy bottoms were rare. Rooted aquatic plants consisted of water willow (*Justica americana* [L.] Vahl), watercress (*Nasturtium officinale* R. Br.) and a few cattails (*Typha latifolia* L.). Filamentous algae were attached to rocks in some riffles but were not widespread.

Livestock and dwellings are potential sources of pollution. The sewage lagoon at Melbourne, two hectares in surface area and designed to accomodate wastes from 850 persons, allows sewage to settle without chemical treatment; effluent then empties through a standpipe into Mill Creek. Melbourne, population 832 in 1970, is the only sizeable community in the watershed.

METHODS AND MATERIALS

Fifteen stations were spaced to provide adequate coverage of the watershed (Fig. 1). Samples and physicochemical data were taken 21-29 July 1972, 25 December 1972 to 20 January 1973 and 7-28 April 1973. Stations M-4 and M-5, just below and above the outflow of the Melbourne lagoon, were not sampled in the summer. Trapping was conducted at stations M-1, P-2, P-4, P-8, P-9 and P-10 on 21-22 October 1972. Supplementary collections were made at locations S-1 and S-2 on 20 January 1973, and at stations P-1, P-2, P-4 and M-3 on 17 February 1973. A rotenone sample was taken at P-4 on 8 June 1973 in cooperation with the Arkansas Game and Fish Commission.

A Hach Water Chemistry Kit, Model AL-36B, was used to determine dissolved oxygen, carbon dioxide, alkalinity and pH at each station during the regular sampling. Turbidity was measured with a Jackson turbidimeter and light penetration was measured with a Secchi disk. Current was determined by timing a floating disk over a distance of 10 m. Water temperature was measured with a Centigrade thermometer.

Fish samples were taken by a 4.6 x 1.2 m seine with bar measure mesh of 0.5 cm, by a 15.2 x 1.8 m bag seine with 0.5-cm bar measure mesh, by an umbrella net 0.9 x 0.9 m with bar measure mesh of 0.6 cm, by rotenone and by fishing with rod and reel. Specimens were hardened in 10% formalin for several days, washed in water and preserved in 40% isopropyl alcohol. Nomenclature agrees with that of Bailey et al. (1970), with the exception of *Okkelbergia* (*Lampetra*) *aepyptera* as suggested by Hubbs and Potter (1971). Preserved weights were determined on a Sargent-Welch triple beam balance or on an Ohaus platform balance.

RESULTS

Physicochemical parameters were generally uniform, although dissolved oxygen, temperature, depth and current fluctuated seasonally. Dissolved oxygen ranged from 7 to 14 mg/liter, and was in excess of 100% saturation at most stations. Carbon dioxide ranged from 5 to 20 mg/liter. Mean pH was 8.5, with extremes of 9.0 and 7.5. Methyl orange alkalinity ranged from 91 to 227 ppm and was generally lower in the April samples. Phenolphthalein alkalinity was not detected. Water temperature ranged from 6 to 31 C; current varied from 0 to 167 cm/sec. Turbidity did not exceed 25 ppm, and the Secchi disk was visible on the bottom except at stations P-5, P-6 and P-10 after heavy rains.

Fishes collected numbered 9,615, representing 44 species (Table I). Pool specimens numbered 5,647 including 32 species, and 3,484 riffle specimens represented 30 species. The 484 fish taken by rotenone, which were not assigned to pool or riffle, constituted 645 fish/ha and 20 kg/ha. *Ictalurus natalis* and *Ambloplites rupestris* were taken only by rotenone. Relative density in other samples ranged from 15,100 to 21 fish/ha, averaging 1,092, 636 and 500 fish/ha in the summer, winter and spring, respectively.

Numbers of fish collected were greatest during the summer and least during spring. Total biomass of fish was greatest during spring and smallest in winter, with extremes of 72 kg/ha at P-7 and 0.1 kg/ha at M-3, M-4 and P-4. Relative density and biomass were generally greatest in headwater pools.

Number of species did not increase substantially at the lower stations. Greatest number of species was at P-4, where 32 forms were taken, including those collected by rotenone. Station P-1 produced 26 species and other stations ranged from 12 to 22 species with the exception of M-4 and M-5 where only 5 and 6 species were taken, respectively.

Notropis telescopus, *Notropis pilsbryi* and *Dionda nubila* were most numerous, totaling 2,393, 2,086 and 1,130 individuals, respectively. *Campostoma anomalum*, *Notropis galactutus*, *Fundulus olivaceus*, *Fundulus catenatus*, *Etheostoma caeruleum* and *Hypentelium nigricans* were common through the streams. *Pimephales notatus*, *Lepomis cyanellus*, *Lepomis macrochirus*, *Lepomis megalotis*, *Micropterus dolomieui*, *Notropis boops* and *Cottus carolinae* were more common in the upper and middle parts of the watershed. *Notropis chrysocephalus*, *Notropis rubellus*, *Cottus bairdi* and *Noturus albater* were more common farther downstream. Several species frequently taken in Piney Creek were rare or absent in Mill Creek, including *Hybopsis amblops*, *Nocomis biguttatus*, *Notropis boops*, *Lepomis macrochirus* and *L. megalotis*. Species collected only in pools were *Pimephales promelas*, *Notemigonus crysoleucas*, *Notropis ozarcanus*, *Erimyzon oblongus*, *Micropterus salmoides*, *M. punctulatus*, *M. dolomieui*, *Lepomis microlophus*, *L. megalotis* and *L. macrochirus*. Those taken only in riffles were *Ichthyomyzon gagei*, *Lampetra lamottei*, *Okkelbergia aepyptera*, *Phoxinus erythrogaster*, *Noturus exilis*, *N. albater*, *Gambusia affinis*, *Etheostoma blennioides*, *E. zonale*, *Cottus bairdi* and *C. carolinae*.

For *N. telescopus*, *N. pilsbryi* and *D. nubila* the mean weights of individuals from pools versus riffles were 1.0 and 0.9 g, 2.6 and 1.5 g and 1.8 and 1.2 g, respectively. The mean weight of these three species showed no discernible trends from headwater to downstream stations.

DISCUSSION

The salient feature of Piney Creek is its diverse ichthyofauna in spite of uniformity of physicochemical parameters. This diversity is due to the variety of habitat, proximity of a large reservoir, and perhaps augmentation by bait-bucket escapes.

The wide range of habitat is due to variation in current and bottom types and pool-riffle zonation. The heterogeneous substrate accounts for variation in breeding sites, shelter and macroinvertebrates. Pools and riffles are well defined in the headwaters, creating niches for specialized forms such as darters and centrarchids. Farther downstream, uniform channel is common, although deep pools and swift riffles are still discernible. Current is highly variable, further diversifying available habitat.

Numerous cyprinids formerly present in North Fork River, now a cold tailwater of Lake Norfork, were mostly absent by 1966, by which time sculpins dominated the ichthyofauna (Hoffman and Kilambi, 1971). Species intolerant of colder

Table I. Numbers of Fishes Collected by Species from 17 Sampling Stations, Piney Creek Watershed, Izard County, Arkansas (Data are based on live sampling except for station P-4 where a rotenone sampling also was conducted.)

Taxa	Stations																	
	P-1	P-2	P-3	P-4	P-4*	P-5	P-6	P-7	P-8	P-9	P-10	M-1	M-2	M-3	M-4	M-5	S-1	S-2
Ichthyomyzon gagei Hubbs and Trautman	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lampetra lamottei (Lesueur)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Okkelbergia aepyptera (Abbott)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campostoma anomalum (Rafinesque)	39	12	7	5	53	18	95	8	5	136	86	16	18	17	0	1	10	0
Dionda nubila (Forbes)	303	70	6	35	10	13	32	0	70	486	13	90	1	0	0	0	1	0
Hybopsis amblops (Rafinesque)	39	5	1	28	82	0	24	20	12	44	3	0	0	0	0	0	9	0
Nocomis biguttatus (Kirtland)	7	11	2	1	18	3	1	3	1	17	2	1	0	0	0	0	11	0
Notemigonus crysoleucas (Mitchill)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Notropis boops Gilbert	2	0	0	2	0	32	89	14	45	0	1	3	0	0	1	0	4	0
Notropis chrysocephalus (Rafinesque)	16	1	5	6	4	2	0	1	0	0	1	1	3	0	0	0	0	0
Notropis galacturus (Cope)	124	30	47	60	10	50	60	59	105	0	1	20	13	78	0	0	6	0
Notropis ozarcanus Meek	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notropis pilsbryi Fowler	418	222	164	90	16	377	176	9	39	198	78	248	28	4	0	0	19	0
Notropis rubellus (Agassiz)	70	19	7	34	7	20	0	1	0	0	0	18	0	0	0	0	0	0
Notropis sabinae Jordan and Gilbert	0	0	0	0	0	0	0	5	0	0	0	0	11	21	0	0	0	0
Notropis telescopus (Cope)	75	201	107	175	5	526	624	69	47	88	138	139	142	5	0	0	51	0
Phoxinus erythrogaster (Rafinesque)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Pimephales notatus Rafinesque	1	0	0	1	4	2	24	37	11	118	21	5	40	24	6	5	4	0
Pimephales promelas Rafinesque	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Semotilus atromaculatus (Mitchill)	0	0	0	1	0	0	0	0	0	2	0	0	0	3	0	0	0	0
Erimyzon oblongus (Mitchill)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Hypentelium nigricans (Lesueur)	7	1	0	1	29	0	0	0	0	6	1	2	2	3	0	0	0	0
Moxostoma duquesnei (Lesueur)	1	0	0	1	20	0	0	3	0	0	0	0	0	1	0	0	5	0
Moxostoma erythrurum (Rafinesque)	4	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	2	0
Ictalurus natalis (Lesueur)	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Noturus albater Taylor	5	3	0	2	12	0	0	0	0	0	0	0	0	0	0	0	0	0
Noturus exilis Nelson	0	1	0	0	2	0	2	1	0	0	0	0	0	0	0	0	0	0
Fundulus catenatus (Storer)	21	18	3	3	0	20	80	55	38	153	13	16	134	190	0	0	2	0
Fundulus olivaceus (Storer)	11	4	1	0	2	7	6	18	15	41	33	0	8	30	3	0	0	0
Gambusia affinis (Baird and Girard)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ambloplites rupestris (Rafinesque)	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepomis cyanellus Rafinesque	0	0	0	0	11	0	0	1	0	2	2	0	0	1	1	1	0	26
Lepomis macrochirus Rafinesque	3	0	0	0	20	1	1	8	0	3	1	0	1	0	0	0	0	0
Lepomis megalotis (Rafinesque)	0	0	0	0	68	0	19	15	8	0	2	0	0	0	1	0	5	0
Lepomis microlophus (Gunther)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Micropterus dolomieui Lacepede	0	0	0	0	11	1	3	2	1	0	0	0	0	0	0	0	0	0
Micropterus punctulatus (Rafinesque)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropterus salmoides (Lacepede)	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Etheostoma blennioides Rafinesque	2	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Etheostoma caeruleum Storer	56	36	6	19	40	2	10	51	6	40	50	1	4	9	0	13	2	0
Etheostoma spectabile Agassiz	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0

	P-1	P-2	P-3	P-4	P-4*	P-5	P-6	P-7	P-8	P-9	P-10	M-1	M-2	M-3	M-4	M-5	S-1	S-2
Etheostoma zonale (Cope)	1	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottus bairdi Girard	4	9	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottus carolinae (Gill)	0	0	0	1	18	0	1	0	0	4	1	0	0	1	0	3	0	0
Totals	1214	644	356	472	484	1075	1247	382	403	1339	447	560	406	390	13	23	134	26

*Rotenone sample

water probably moved downstream to White River which may have served as a route of dispersal to warmer water. As Piney Creek is the first significant warmer tributary downstream, its ichthyofauna may well include immigrant species that were originally rare or absent prior to the completion of Norfork Dam in 1944.

Lake Norfork remains a potential source of fish typical of small Ozark streams. *M. salmoides*, taken twice in this survey, is more characteristic of lentic habitat (Pflieger, 1971) and is common in reservoirs. *M. punctulatus*, collected once, at the lowest station, is abundant in lakes and some larger rivers but is less common in cooler spring-fed streams where it usually is replaced by *M. dolomieui* (Pflieger, 1971). Two specimens were taken of *N. crysoleucas*, a form more characteristic of lentic habitat and abundant in backwaters of some large reservoirs (Pflieger, 1971). One *P. promelas* was collected, at station M-5, where dissolved oxygen was slightly below average. *N. crysoleucas* is sporadic, and *P. promelas* rare, in natural Ozark waters (Pflieger, 1971) but both are propagated at hatcheries and used as bait fish. These four species are not likely to be indigenous to Piney Creek and probably came from Lake Norfork or White River, or were bait-bucket transfers.

L. lamottei, *O. aepyptera* and *I. gagei*, all taken in fast riffles, represent additional diversity. Numerous locations in lower Piney Creek were well suited for these forms, as fast deep riffles needed for spawning led into slow water flowing over silty sand, in which ammocetes could mature. The only other Arkansas specimen of *O. aepyptera* was taken from the South Fork River about two weeks prior to this capture (Harp and Matthews, in press). Two gravid *L. lamottei* were collected 17 February 1973, earlier than the usual spawning season for this species (Harp and Matthews, in press).

Sand and silt were probably the major limiting factors to fish distribution in the watershed. No distinctive correlations could be demonstrated between distribution and physicochemical parameters, and the measured chemical environment never exceeded limits of tolerance for fish. The lower parts of the streams were characterized by unstable silty sand, which limited some catostomids and centrarchid breeding sites. During floods large quantities of sand and silt filled existing pools and riffles and scoured new ones. After unusual flooding in 1973, severe erosion of sand and earth banks was noted. By October 1973, at station P-1, a rocky riffle that had varied from 30 to 60 cm through the past year and had yielded three lampreys was filled with sand, becoming a shallow channel, and a pool that had been 136 cm deep in July 1972 was filled to a depth of a few centimeters. The unstable substrate caused communities in the lower parts of the watershed to be variable and was not conducive to stable populations. Increased sedimentation seems likely to increase siltiness and destroy habitat, possibly causing extirpation of some species from the watershed.

Stations M-4 and M-5 were unique in that they yielded markedly fewer specimens or species than the other stations. Effluent from the Melbourne lagoon probably influenced the stream, although the physicochemical parameters measured at these locations did not support this hypothesis. A reduction in numbers of species near sewage has been reported by Wade and Craven (1966) and Beadles (1970).

Recurrence of habitat types precluded well-defined longitudinal zonation, but accentuated pool-riffle zonation as headwater species reappeared in similar habitats farther downstream. Additionally, small tributaries may have provided headwater-like habitat lower in the watershed. Ten species were taken only from pools and 11 species were captured only in riffles. Dominant riffle forms included darters, particularly *E. caeruleum*, sculpins and madtoms. *N. albater*, *C. bairdi* and *E. caeruleum* frequently were associated in fast deep riffles. The centrarchids were taken most often in pools, notably *L. megalotis*, *L. cyanellus*, *L. macrochirus* and *M. dolomieui*. In pools and along undercut banks *P. notatus*, *D. nubila*, *C. anomalum*, *H. amblops*, *N. biguttatus*, *N. boops*, *N. sabinae* and *N. galacturus* were more common; other cyprinids exhibited no such behavior. The *Fundulus* species were more common in pools and in some backwaters.

The most abundant species numerically, accounting for 58% of all specimens, were *N. telescopus*, *N. pilsbryi* and *D. nubila*. Black (1940) considered *N. telescopus* and *N. pilsbryi* endemic to clean cool waters of the Ozarks, and *D. nubila* as characteristic of, though not limited to, the White and Neosho River drainages. All three were abundant through most of the watershed in diverse habitats. *D. nubila* was more common in pools, and the two *Notropis* usually were not taken in extremely fast riffles. In this study the allopatric distribution of *N. pilsbryi* and *Notropis zonatus* (Agassiz) (Black, 1940; Hubbs and Moore, 1940) seemed to be maintained, although Jackson and Harp (1973), collecting in an adjacent White River tributary, reported them sympatric.

Several species were scarce in the watershed. *P. erythrogaster* was taken only once, although the numerous springs characteristic of this watershed should permit more widespread distribution. *N. ozarcanus* was collected only once, from a deep fast pool with a gravel and sand bottom. One *E. oblongus* was taken in a trap at P-9, although collecting in extreme headwaters might yield more specimens. *E. spectabile*, reported common in small Ozark streams by many authors, was taken only twice, apparently because of interspecific competition with *E. caeruleum*. One *G. affinis* was taken in a shallow gravel-bottomed riffle, and the only *L. microlophus* was collected from an isolated headwater pool during drought conditions.

N. pilsbryi and *D. nubila* in pools averaged respectively 1.7 and 1.5 times the weight of riffle individuals. This difference may reflect the dominance of larger individuals in pools, which are more favorable because of abundance of benthic and drift organisms, better shelter and less current. The lower energy requirement in pools is of greater survival value to larger individuals which have a lower overall energy efficiency (Lagler et al., 1962).

Fowler and Harp (1974) reported 392 kg of fish/ha from a rotenone sample compared with 20 kg/ha in the present rotenone collection. Fish density, which ranged from 21 to 15,100 fish/ha, was greatest in headwater pools. Jackson and Harp (1973) reported a range of 12,000 to 34,000 fish/ha on Big

Creek and Robison and Harp (1971) reported means values of 242 and 185 fish/ha at two stations on Strawberry River. Biomass data may be influenced by concentrations of fish and are difficult to compare because of inequity of sampling effort between studies. In this study two species, *I. natalis* and *A. rupestris*, were taken only by rotenone, a fact which emphasizes the possible bias of various sampling techniques.

N. sabinae was collected in small numbers at three stations, primarily in swift pools below rapids. No other investigator has reported *N. sabinae* from a small Ozark stream. Black (1940) reported it a rare and poorly known species inhabiting large sandy-bottomed rivers. Cashner (1967) reported it as occasional in pools and slow riffles of the lower White and Black Rivers. In Missouri, Pflieger (1971) described the species as limited to a clear, narrow and deep section of Black River over a bottom of fine silt-free sand. In this study the Sabine shiner was taken most often in Mill Creek, which is sandier than most of Piney Creek. The collection of *N. sabinae* from the Piney Creek watershed constituted a westward extension of its known range.

ACKNOWLEDGEMENTS

The writers express sincere appreciation to Drs. J.K. Beadles and D.H. Sifford who served as thesis committee members and to Drs. Beadles, G.A. Moore of Oklahoma State University, H.W. Robison of Southern State College and E.H. Lachner of the U.S. National Museum, who aided in identification of certain specimens. R. Baker, M. Schmidt and Y.D. Whitehurst performed the rotenone kill under the auspices of the Arkansas Game and Fish Commission and R.S. Matthews, D. House and C. Latimer assisted in field work. S. Matthews typed and helped prepare tables and the Warren County R-III School District, Warrenton, Missouri, provided financial assistance.

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